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Ahn et al.

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- (54) **ROLLABLE DISPLAY DEVICE**
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H05K 5/02 (2006.01)
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CPC **H05K 5/0217** (2013.01); **H05K 5/0018** (2022.08)
- (58) **Field of Classification Search**
CPC H05K 5/0217; H05K 5/0018
See application file for complete search history.

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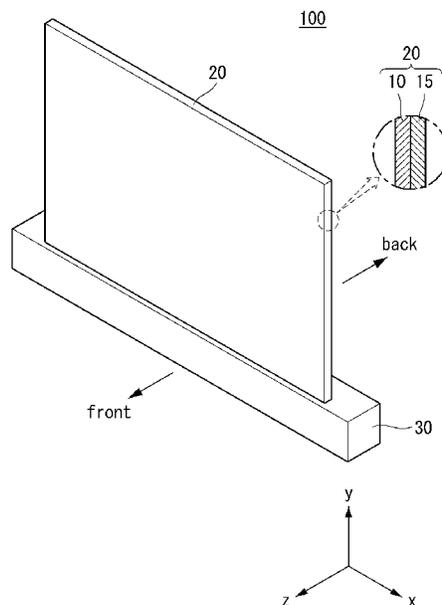
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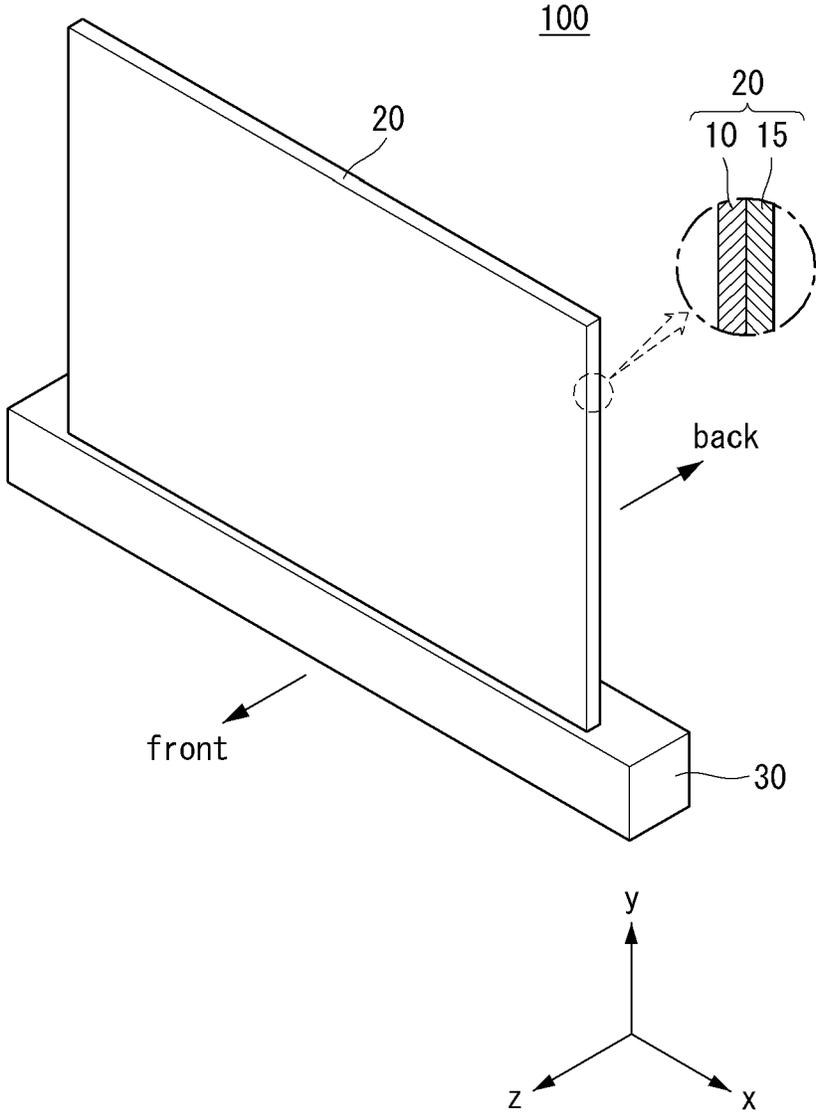
(57) **ABSTRACT**

The present disclosure relates to a rollable display device comprising: a roller; a display part on which the roller rolls and which comprises a display panel and a module cover adjoining and facing the display panel; a supporter fixed to an end portion of the display part; a link assembly comprising an upper link rotatably mounted on the supporter and a lower link connected to the upper link through a joint; and a motor assembly for rotating the lower link; wherein the module cover comprises a first skin and a second skin facing the first skin and having a buckling stress greater than that of the first skin, and the module cover is joined to the display panel so that the second skin thereof faces the display panel.

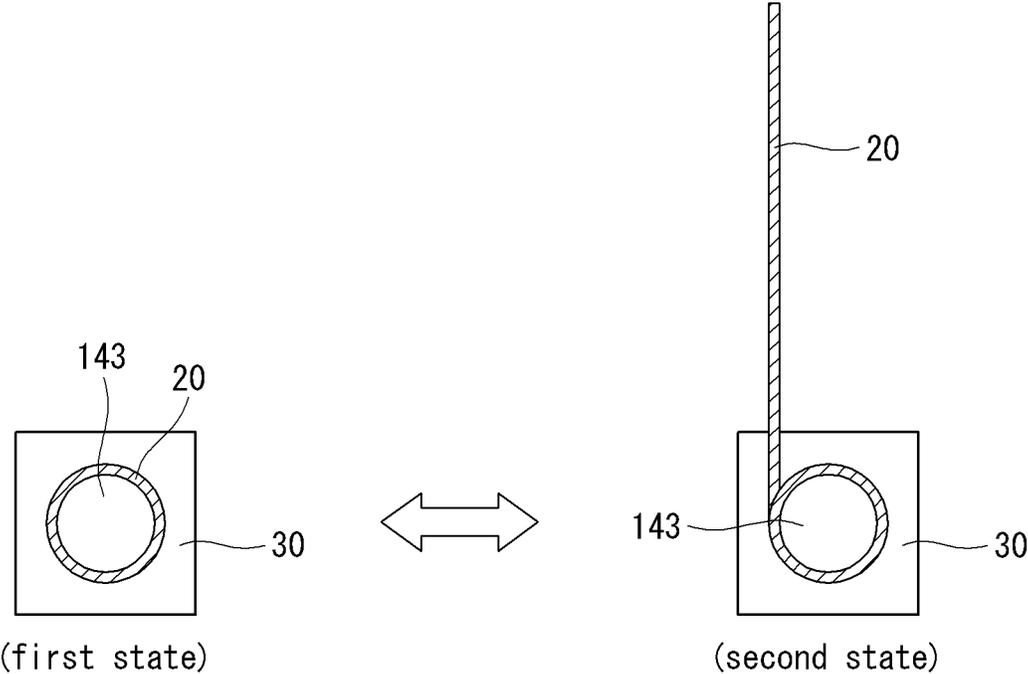
19 Claims, 20 Drawing Sheets



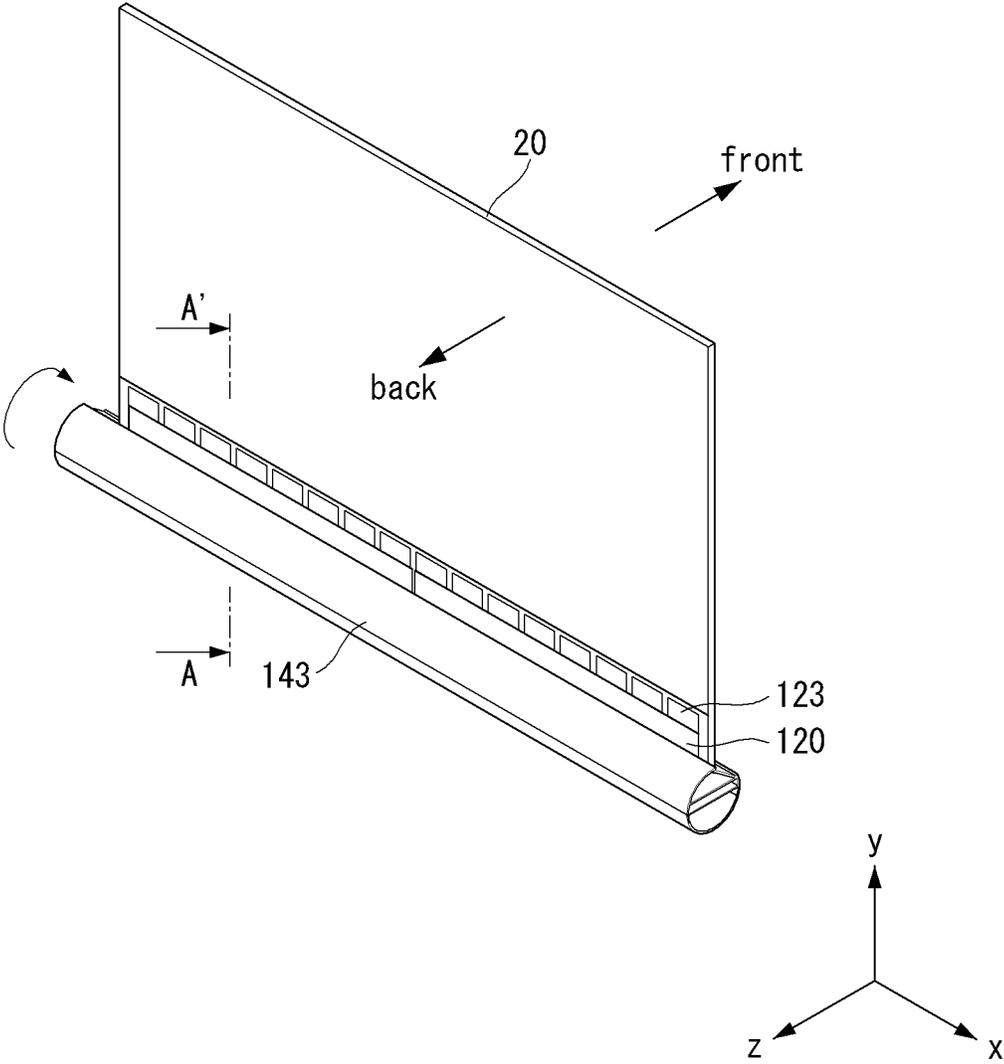
[Fig. 1]



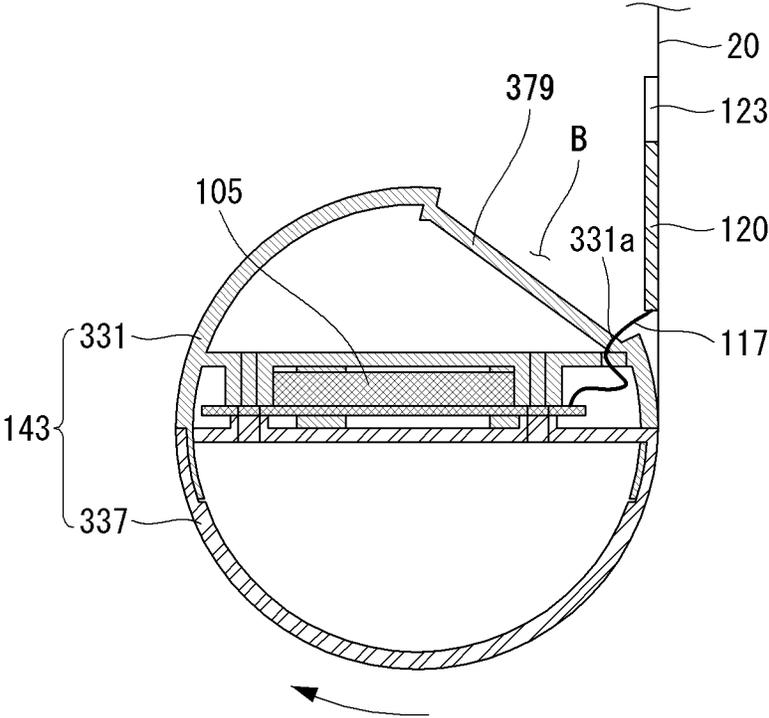
[Fig. 2]



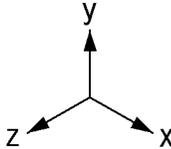
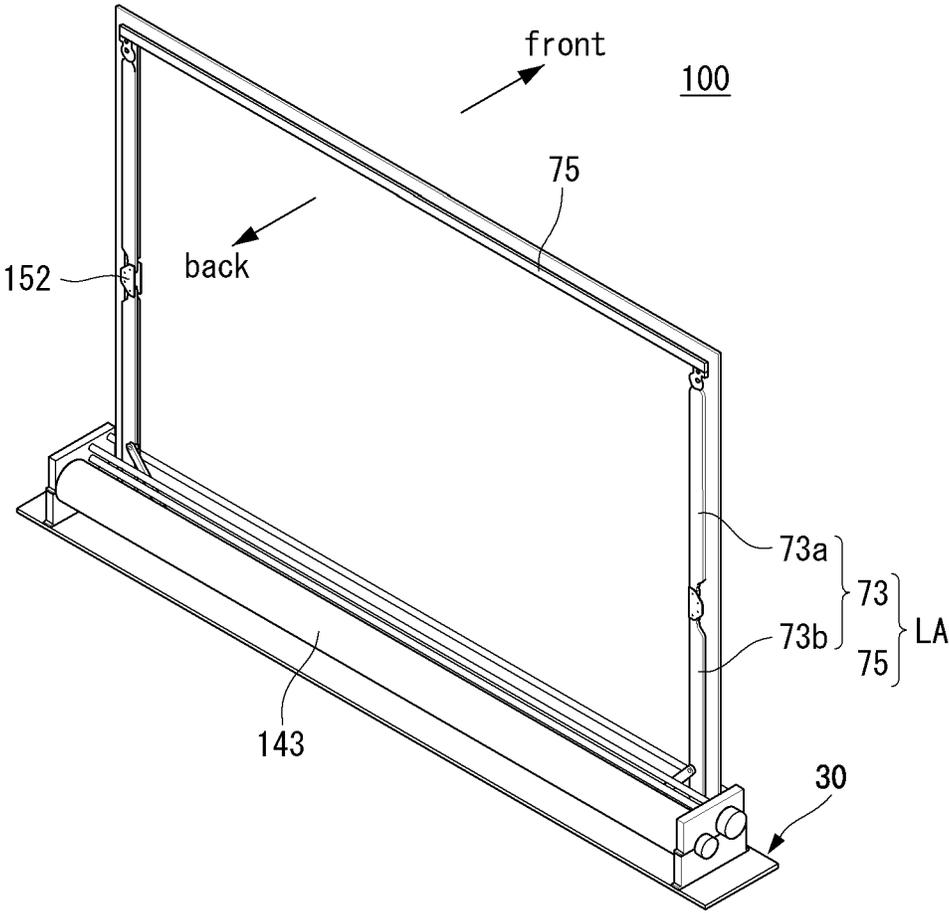
[Fig. 3]



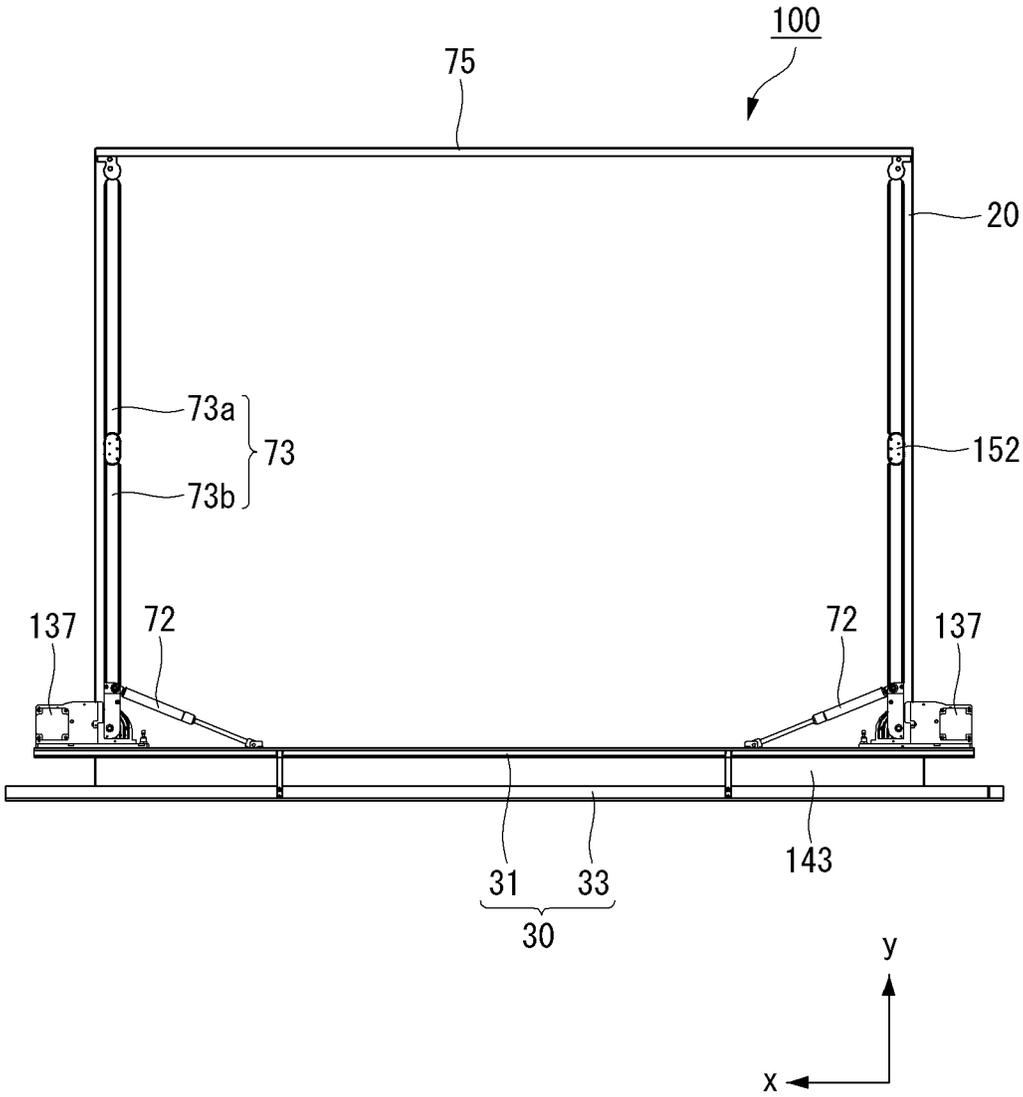
[Fig. 4]



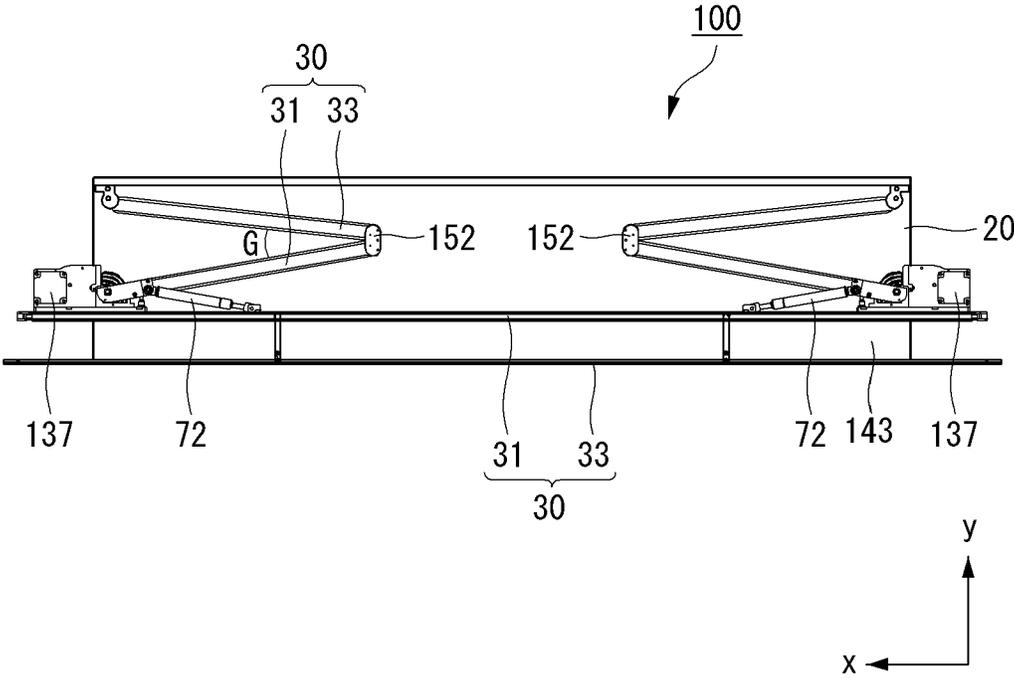
[Fig. 5]



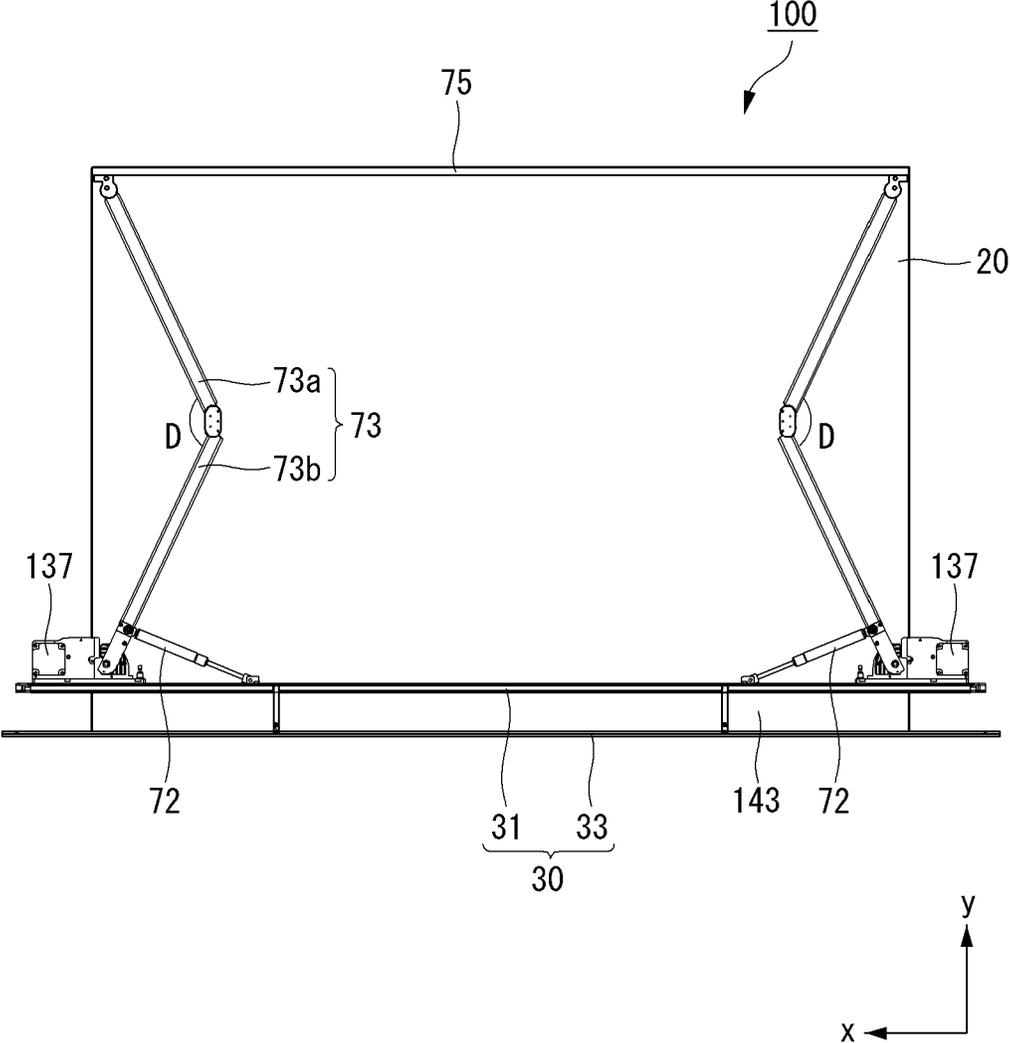
[Fig. 6]



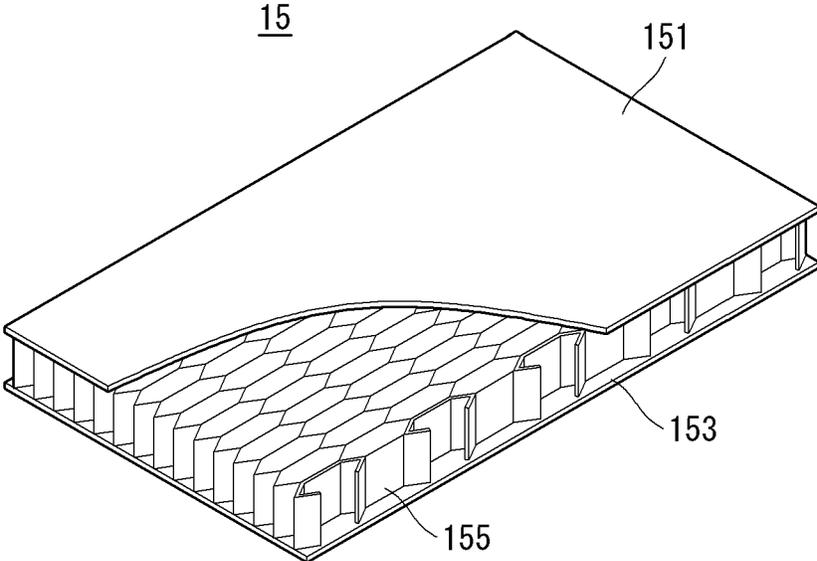
[Fig. 7]



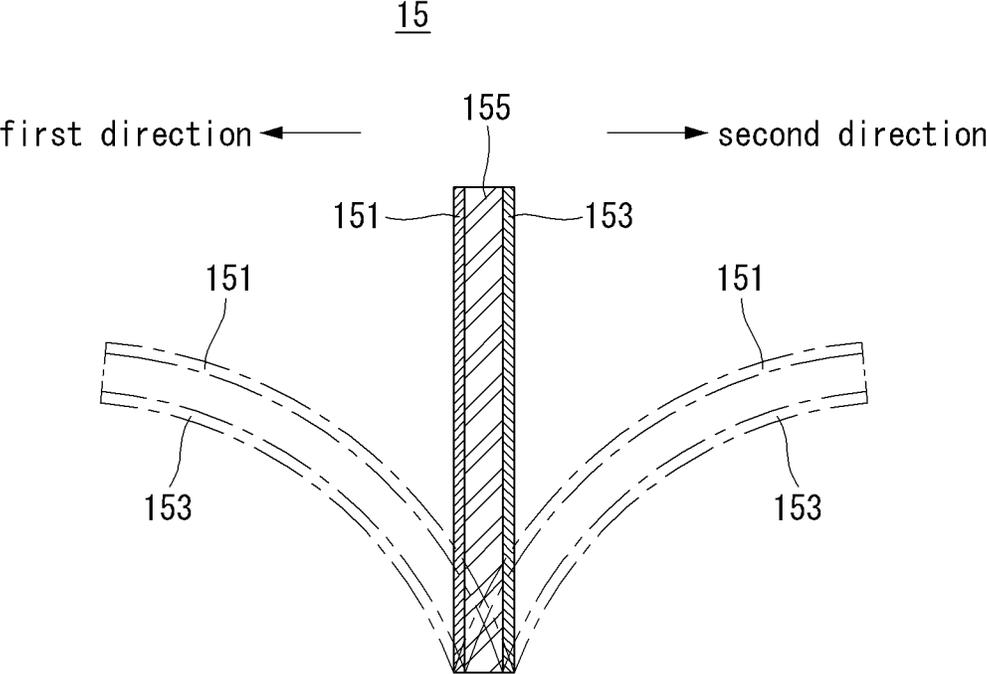
[Fig. 8]



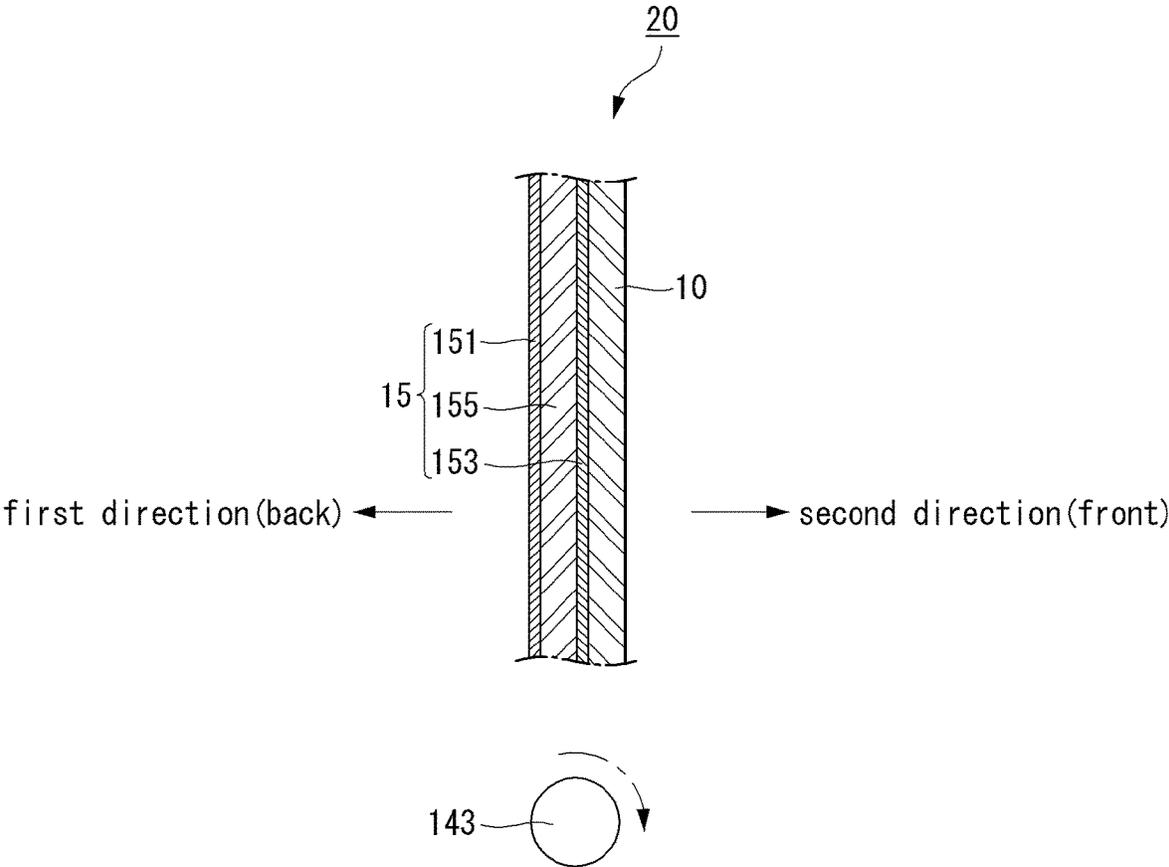
[Fig. 9]



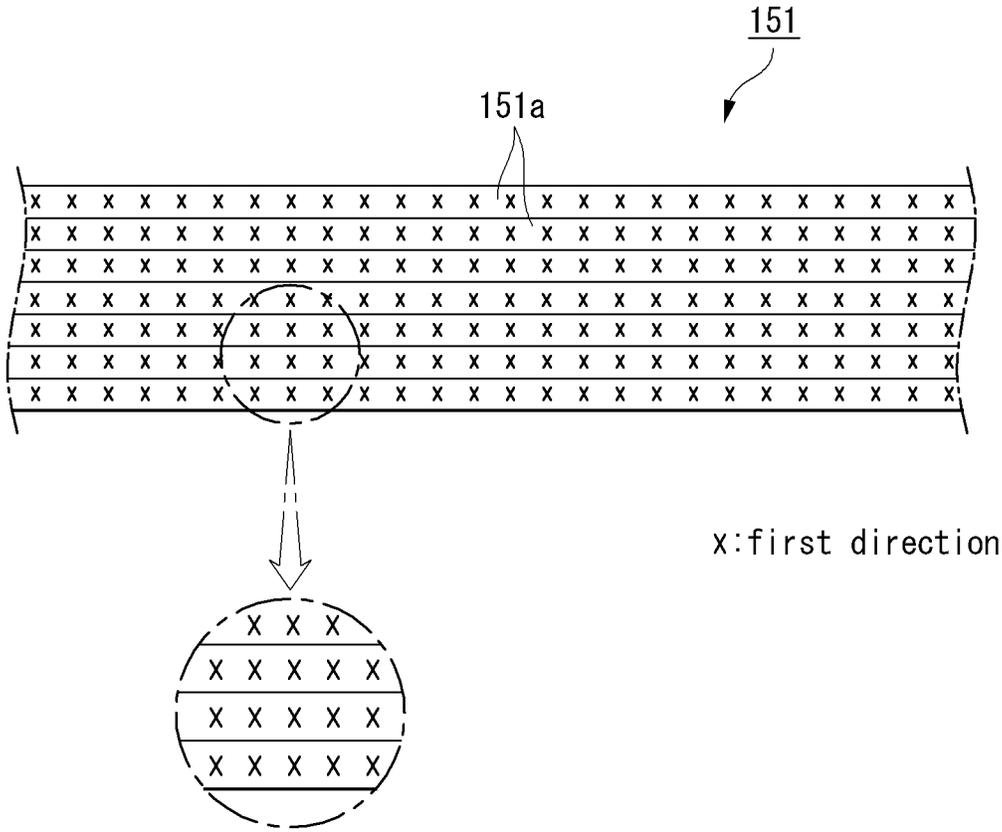
[Fig. 10]



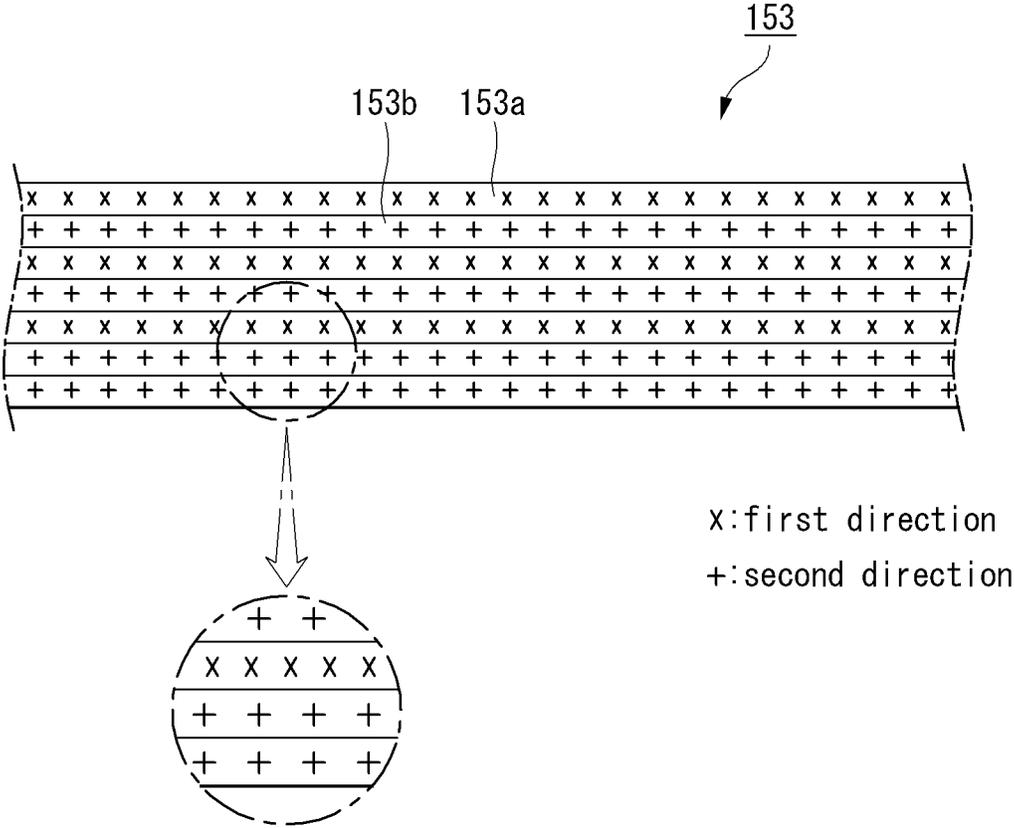
[Fig. 11]



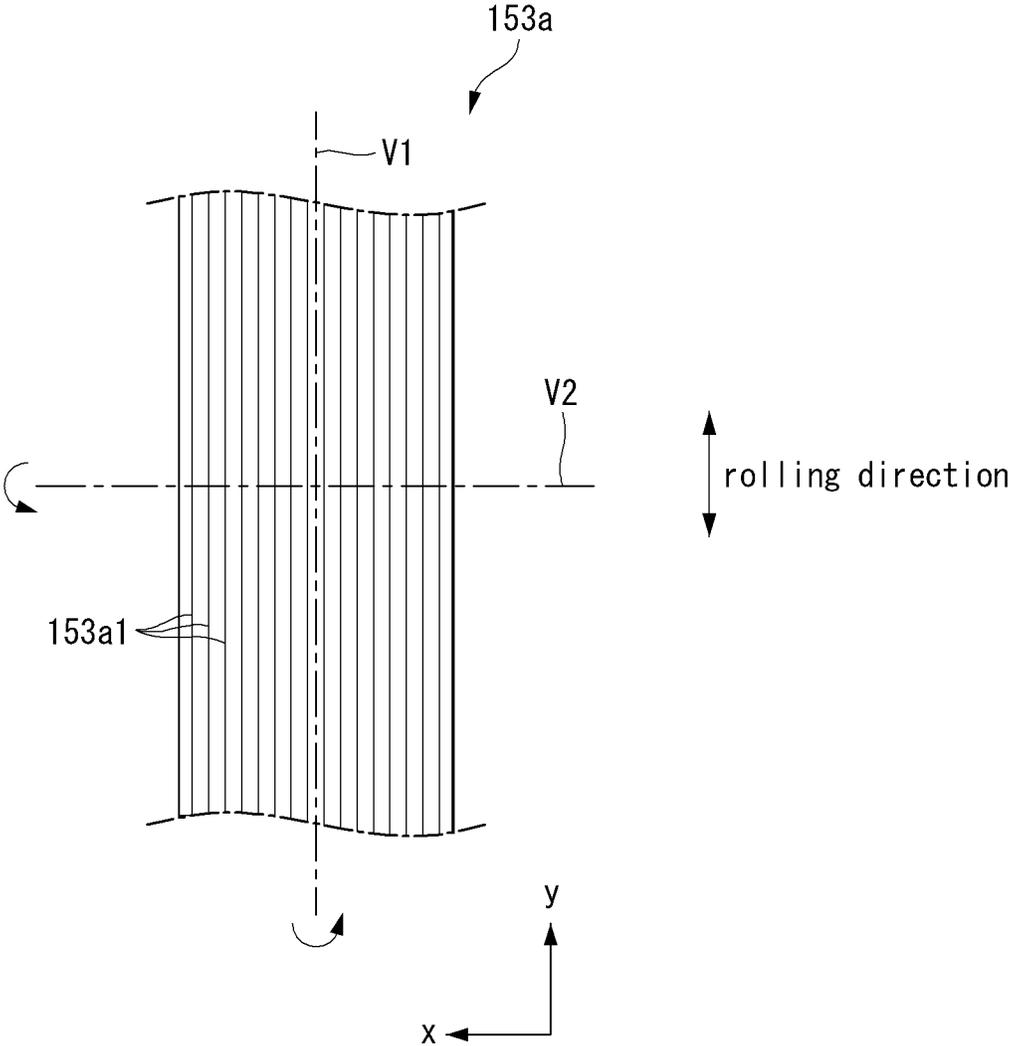
[Fig. 12]



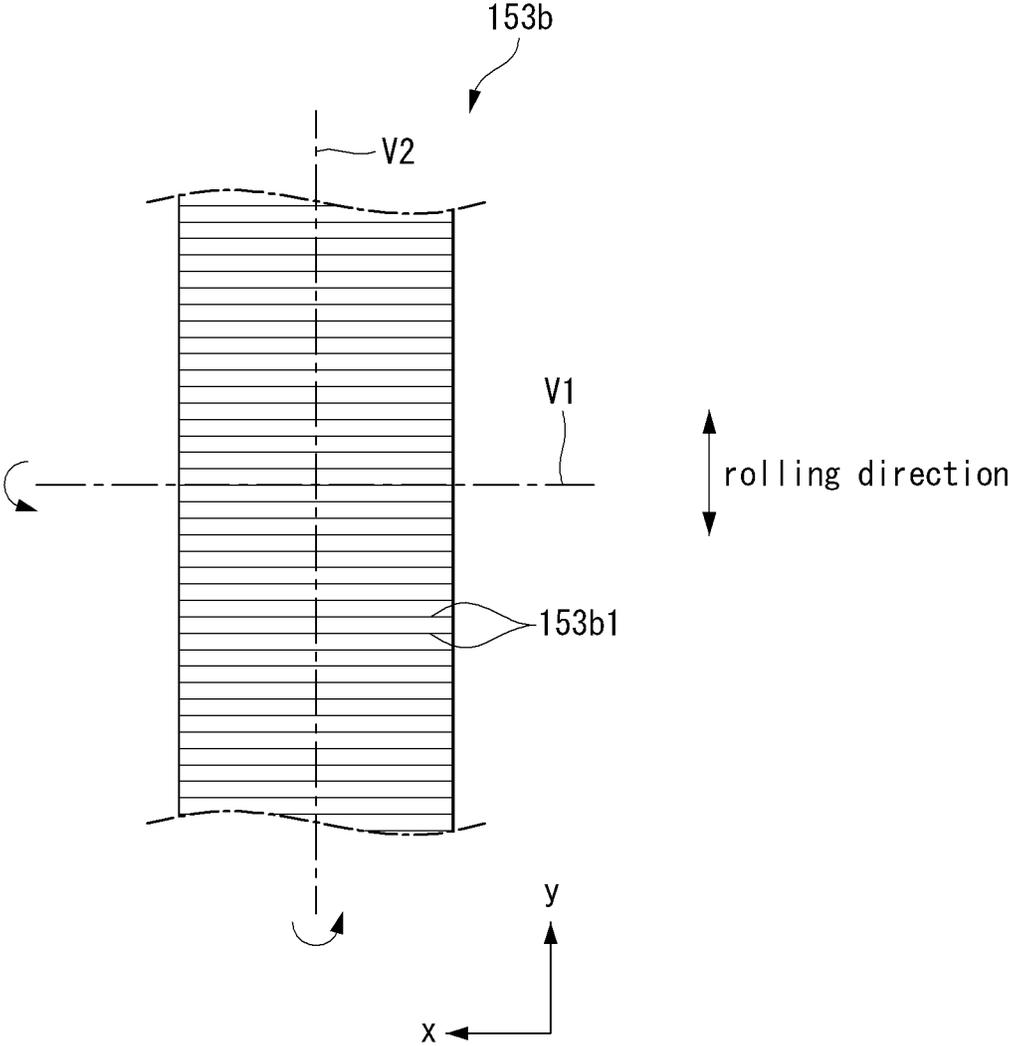
[Fig. 13]



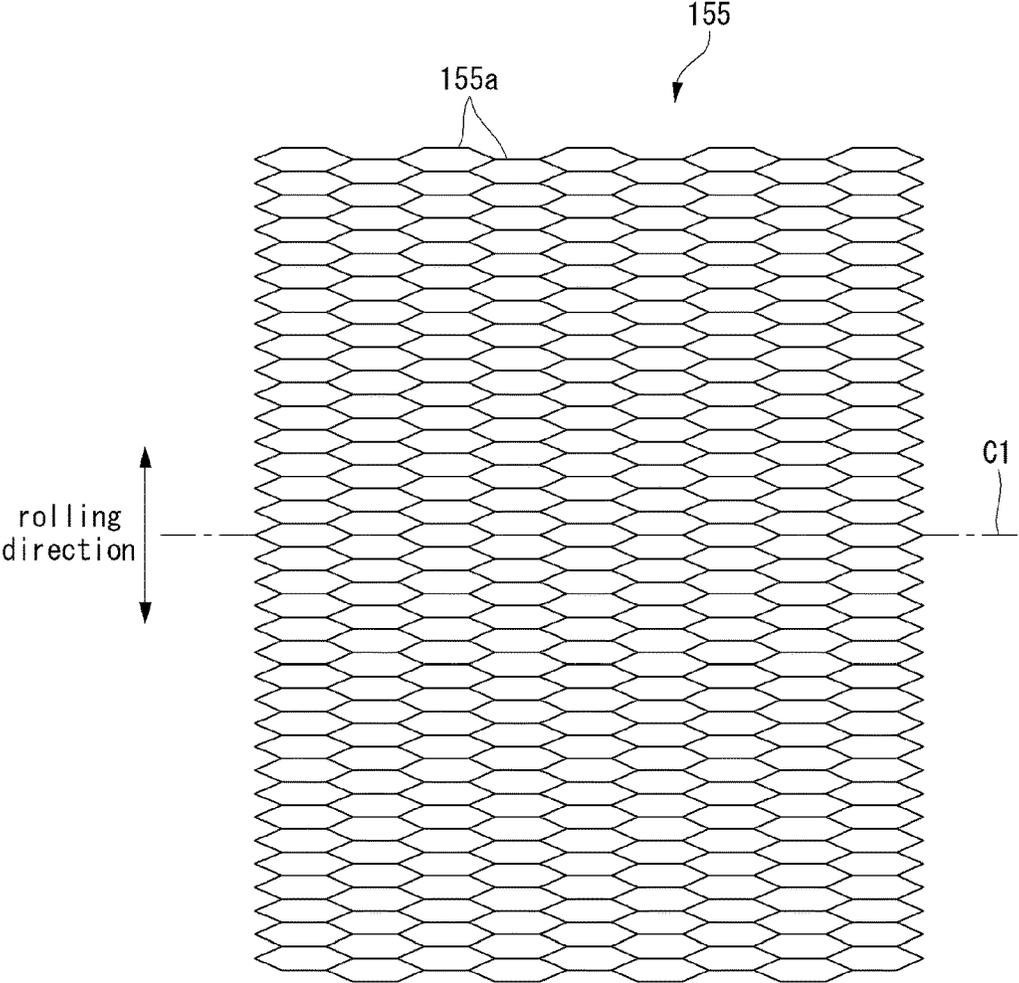
[Fig. 14]



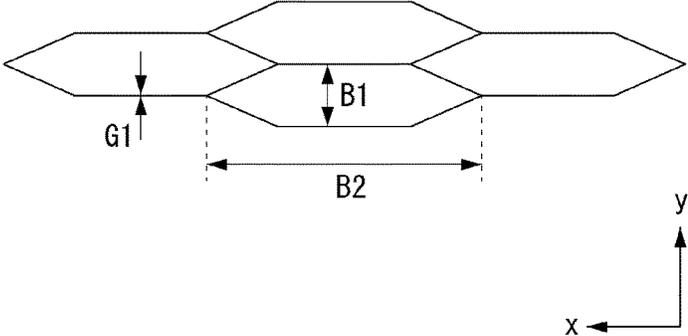
[Fig. 15]



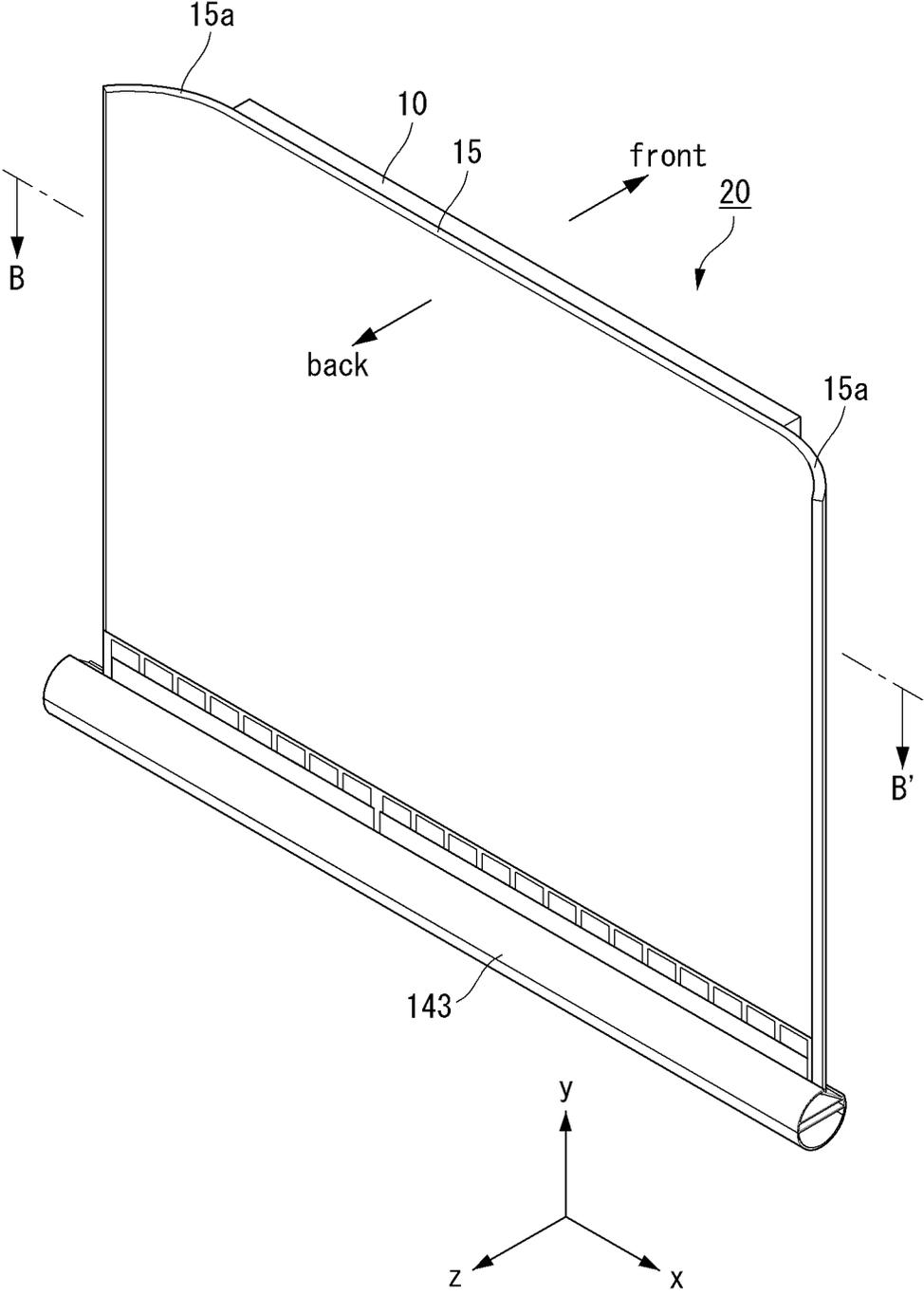
[Fig. 16]



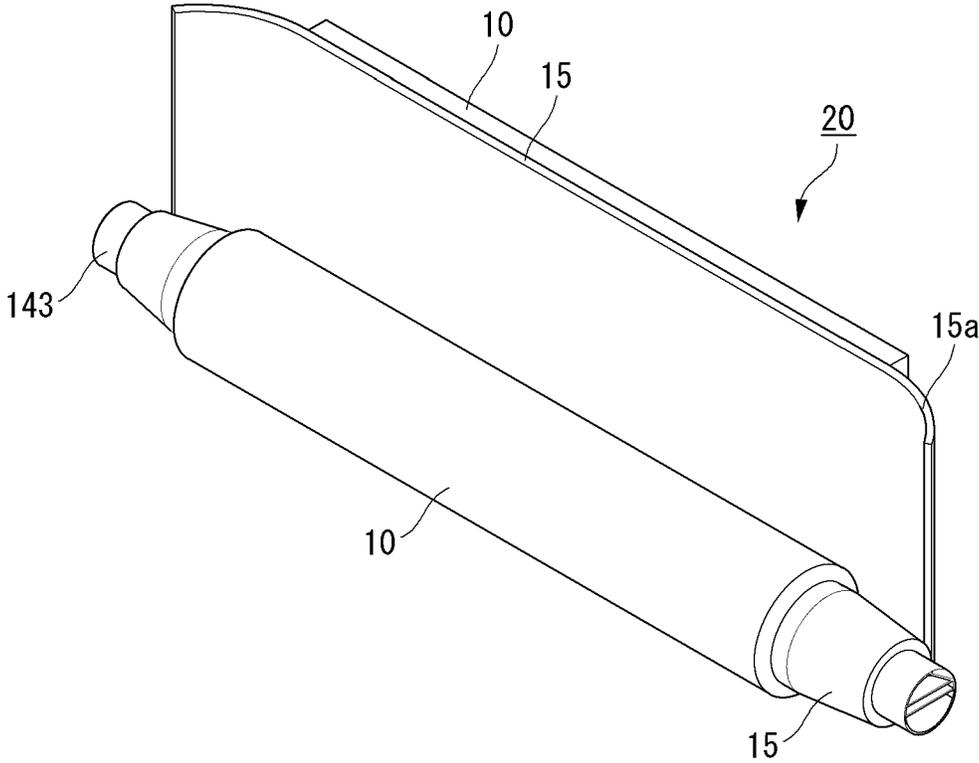
(A)



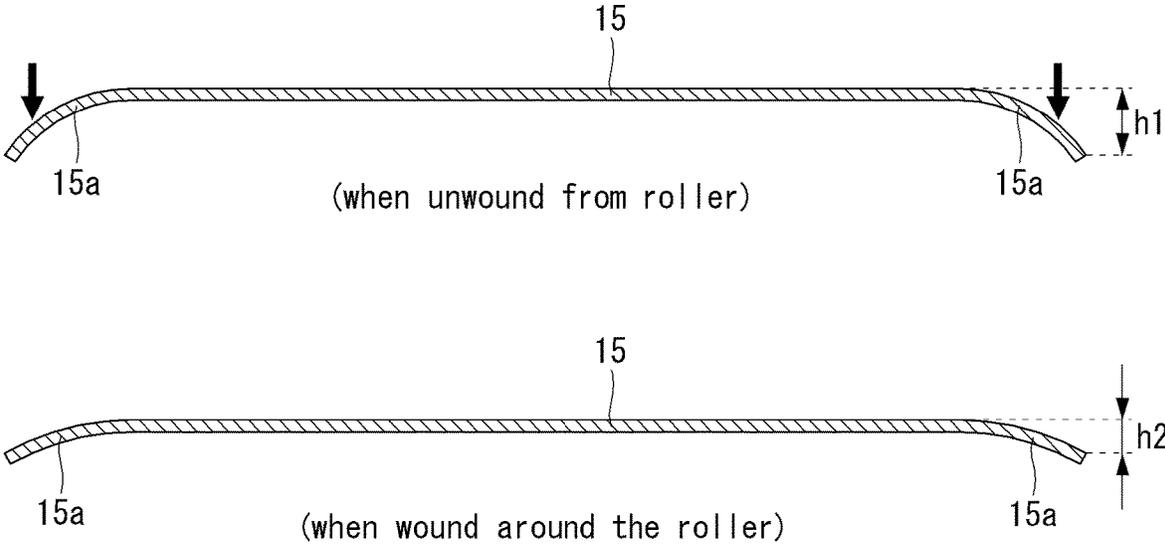
[Fig. 17]



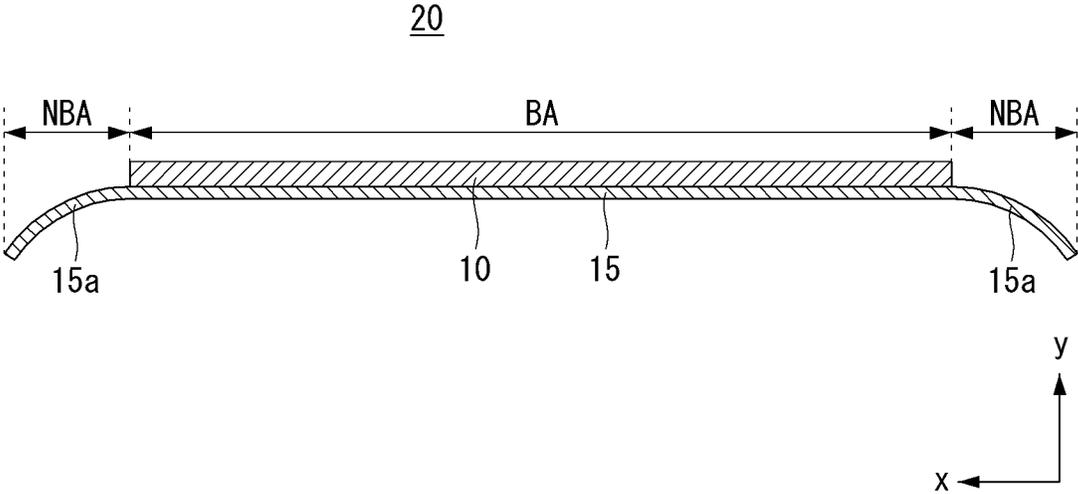
[Fig. 18]



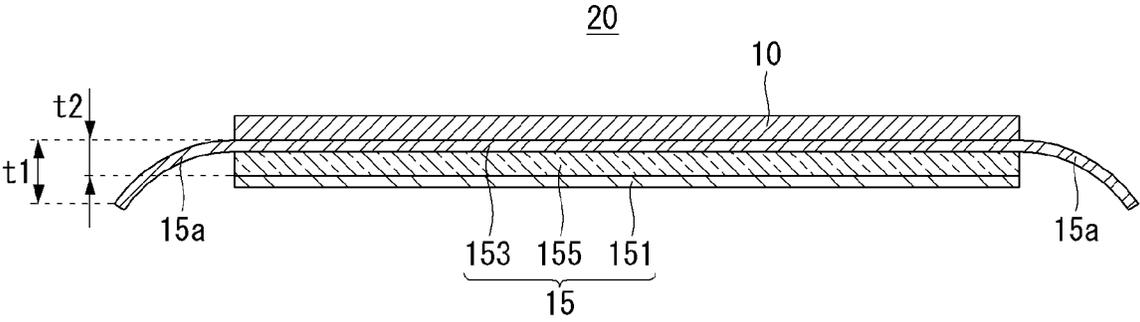
[Fig. 19]



[Fig. 20]



[Fig. 21]



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ROLLABLE DISPLAY DEVICE**CROSS REFERENCE TO RELATED APPLICATIONS**

This application is the National Phase of PCT International Application No. PCT/KR2019/009407, filed on Jul. 29, 2019, all of which is hereby expressly incorporated by reference into the present application.

TECHNICAL FIELD

The present disclosure relates to a rollable display device on which a display rolls.

BACKGROUND ART

Along with the development of information society, the demand for display devices is increasing in various forms. To meet this demand, various types of display devices such as liquid crystal displays (LCDs), plasma display panels (PDPs), electroluminescent displays (ELDs), and vacuum fluorescent displays (VFDs), have been studied and used in recent years.

Among them, display devices using organic light emitting diodes (OLEDs) are advantageous in that they can be implemented as ultrathin and flexible displays since they have luminance characteristics and viewing angle characteristics, compared to liquid display devices, and require backlight units.

Moreover, flexible displays are applied and used in various fields. For example, they may be implemented as rollable display devices that can be unrolled when the display is in use and that can be rolled up and kept in storage when the display is not in use.

SUMMARY

The present disclosure has been made in an effort to solve the aforementioned problems and other problems.

An aspect of the present disclosure is to provide a module cover that can be used in a rollable display and a rollable display device including the same.

A rollable display device according to an embodiment of the present disclosure may include: a roller; a display part on which the roller rolls and which includes a display panel and a module cover supporting the display panel, the module cover including a bending portion at both end portions of the display part, which bends toward the roller in a second direction intersecting a first direction in which the display part rolls, with a first side facing the roller and a second side facing the display panel having different bending strengths, wherein a first height of the bending portion at which the display part is unrolled from the roller is different from a second height thereof at which the display part is rolled up around the roller.

The second side may be a side where the display panel is joined to the module cover, and the bending strength of the second side may be greater than the bending strength of the first side.

The ratio h_1/h_2 of the first height h_1 and second height h_2 of the bending portion may be from 1 to 5.

The module cover may include a first skin and a second skin facing the first skin and having a buckling stress greater than that of the first skin, and the module cover may be joined to the display panel so that the second skin faces the display panel.

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The first skin may contain less polymer matrix composites than the second skin or contain no polymer matrix composites.

The difference in buckling stress between the first skin and the second skin may be 10 or greater.

At least one of the first skin and the second skin may contain reinforced fiber, and a first reinforced fiber included in the first skin may be woven in a different way from a second reinforced fiber included in the second skin.

The second reinforced fiber may include first sub skins with original yarns arranged only in a first direction and second sub skins with original yarns woven in a second direction orthogonal to the first direction, wherein the first direction may be the same as the direction in which the display part rolls, and the number of first sub skins may be larger than the number of second sub skins.

The thickness of the second skin may be equal to or larger than that of the first skin and may be equal to or smaller than 1 mm.

The first reinforced fiber may only include a plurality of sub skins woven in the first direction.

The rollable display device may further include a core sandwiched between the first skin and the second skin.

The core may have a honeycomb structure including hexagonal columns, wherein the width of the hexagonal columns in the first direction may be smaller than the width thereof in the rolling direction.

The ratio B_2/B_1 of the width B_2 in the second direction and the width B_1 in the first direction may be from 1.5 to 7.

The ratio B_1/G_1 of the thickness G_1 of the hexagonal columns and the width B_1 in the first direction may be from 3 to 20.

The thickness of at least one of the first and second skins may be equal to or smaller than the bending strength of the core.

The second skin may be joined to the core by an adhesive layer, and the shore hardness of the adhesive layer may be 80 or smaller.

The bending portion may be selectively formed only on an end portion of the second skin.

The height of the bending portion may be greater than the sum of the thickness of the first skin and the thickness of the core.

The rollable display device may further include: a link assembly including a supporter fixed to an end portion of the display part, an upper link rotatably mounted on the supporter, and a lower link connected to the upper link through a joint; and a motor assembly for rotating the lower link.

Advantageous Effects

The effects of a display device according to the present disclosure will be described below.

According to at least one of the embodiments of the present disclosure, a lightweight, plate-like module cover is provided to make rolling of the display easy.

The additional scope of applicability of the present disclosure will be apparent from the above detailed description. However, those skilled in the art will appreciate that various modifications and alterations are possible, without departing from the idea and scope of the present disclosure, and therefore it should be understood that the detailed description and specific embodiments, such as the preferred embodiments of the present disclosure, are provided only for illustration.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a simplified view of the overall appearance of a rollable display device according to an embodiment of the present disclosure.

FIG. 2 is a view illustrating an operation of a rollable display device.

FIG. 3 is a view showing the appearance of a display part connected to a roller.

FIG. 4 is a view schematically showing a cross-section taken along the line A-A' of FIG. 3.

FIG. 5 is a view showing the overall appearance of a rollable display device according to an embodiment.

FIG. 6 is a view showing the appearance of a back of the rollable display device of FIG. 5.

FIGS. 7 and 8 are views showing a link assembly in a folded state.

FIG. 9 is a view showing the appearance of a module cover according to one embodiment.

FIGS. 10 and 11 are views illustrating bending of the module cover.

FIGS. 12 and 13 are views illustrating cross-section structures of a first skin and a second skin, respectively.

FIGS. 14 and 15 are views illustrating the direction of arrangement of reinforced fiber.

FIG. 16 is a view showing a plane pattern of a core.

FIG. 17 is a view showing a display part connected to a roller according to an embodiment.

FIG. 18 is a view showing the display part of FIG. 17 wound around a roller.

FIG. 19 is a view showing cross-sections of the module cover of FIG. 17 when wound around the roller and when unwound from the roller.

FIG. 20 is a view showing the display part of FIG. 17 taken along the line B-B'.

FIG. 21 is a view showing another construction of a bending portion.

DETAILED DESCRIPTION OF THE EMBODIMENTS

Hereinafter, embodiments disclosed in the present disclosure will be described in detail with reference to the accompanying drawings and the same or similar components are denoted by the same reference numerals regardless of a sign of the drawing, and duplicated description thereof will be omitted. Suffixes “module” and “portion” for components used in the following description are given or mixed in consideration of easy preparation of the present disclosure only and do not have their own distinguished meanings or roles. Further, in describing the embodiment of the present disclosure, a detailed description of related known technologies will be omitted if it is determined that the detailed description makes the gist of the embodiment disclosed in the present disclosure unclear. Further, it is to be understood that the accompanying drawings are just used for easily understanding the embodiments disclosed in the present disclosure and a technical spirit disclosed in the present disclosure is not limited by the accompanying drawings and all changes, equivalents, or substitutes included in the spirit and the technical scope of the present disclosure are included.

In addition, in the drawings, for a simplified illustration according to selection, the components of each part may be expressed slightly differently according to the drawings, but the same reference numerals represent the same components.

Hereinafter, a display panel will be described by taking an organic light-emitting display (OLED) as an example. However, display panels applicable to the present disclosure are not limited to liquid crystal panels, but may include flat panel displays that are configured to be bendable, such as liquid crystal display devices (LCDs), plasma display panels (PDPs), or field-emission display panels (FEDs).

Hereinafter, the overall appearance and operation of a rollable display device according to an embodiment of the present disclosure will be described with reference to FIGS. 1 and 2. FIG. 1 is a simplified view of the overall appearance of a rollable display device according to an embodiment of the present disclosure. FIG. 2 is a view illustrating an operating state of the rollable display device.

Referring to FIGS. 1 and 2, the rollable display device **100** according to an embodiment may include a display part **20** and a housing **30**.

The display part **20** is a component that displays images, which may be configured to include a display panel **10** and a module cover **15**.

The display panel **10** is provided on the front of the display device **100** and displays images. The display panel **10** may split an image into a plurality of pixels and output the image by controlling each pixel to emit light by adjusting the color, brightness, and saturation of each pixel. The display panel **10** may be divided into an active region where an image is displayed and an inactive region where no image is displayed.

The display panel **10** may be rectangular. However, the display panel **10** is not limited to this shape and also may be shaped to have a predetermined curvature at the corners. The display panel **10** may be an organic light-emitting diode (OLED) panel in an exemplary embodiment. However, the present disclosure is not limited to this, and the display panel **10** may be various types of flat panel displays that are bendable.

The module cover **15** may be provided on the back of the display panel **10**. The module cover **15** may be attached directly to the display panel **10**. The module cover **15** may be the same size as or larger than the display panel **10**.

The module cover **15** may support the display panel **10**, and also may be attached directly to the back of the display panel **10**, with a surface of the module cover **15** facing a surface of the display panel **10**, so that the display panel **10** rolls in a stable manner. In an exemplary embodiment, the module cover **15** may be joined to the display panel **10** by an adhesive having a given strength or higher once it is cured. As a result, the display panel **10** and the module cover **15** may be integrated into one assembly and operate as a single body.

This module cover **15** may be configured to raise or lower the display part **20** and to bend well or not depending on the direction. To this end, the module cover **15** will be described in detail later.

The housing **30** may hold the display panel **10** in it, and multiple mechanical components for raising the display part **20** and driving circuits required to drive the display part **20** may be mounted inside it.

The rollable display device **100** may operate in a first state and a second state. The first state is a state in which the active region of the display part **20** is positioned inside the housing **30**, and the second state is a state in which the active region of the display part **20** is exposed out of the housing **30**. Or else, the first state may be a state in which the display part **20** is held inside the housing, and the second state may be a state in which the display part **20** is unrolled.

When the rollable display device **100** is in the first state, the active region of the display part **20** may be positioned inside the housing **30**. That is, this means that the display part **20** may be covered by the housing **30**.

The rollable display device **100** maintains the first state when it does not operate or no screen appears on the display, and maintains the second state when it operates or a screen appears on the display.

In an embodiment, the rollable display device **100** may further include a roller **143** for raising the rollable display device **100**. The roller **143** is configured to rotate clockwise or counterclockwise within the housing **30**. One end of the display part **20** is connected to the roller **143**, and may be unfolded out of the housing **30** or held inside the housing **30** as the display part **20** is raised by the rotation of the roller **143**.

Otherwise, in the first state, the display part **20** is rolled up around the roller **143**, and in the second state, the display part **20** is unrolled from the roller **143** and exposed. A detailed structure and operation method of the display part **20** will be described below.

As such, in the rollable display device **100** according to an embodiment, the display part **20** may be in either the first state or the second state. Accordingly, the display part **20** may be exposed out of the housing **30** only when the display device **100** is in use, thereby saving space.

Hereinafter, the configuration of the display part **20** and the roller **143** will be described in detail with reference to FIGS. **3** and **4**. FIG. **3** is a view showing the display part being connected to the roller. FIG. **4** is a view schematically showing a cross-section taken along the line A-A' of FIG. **3**.

Referring to FIGS. **3** and **4**, in the rollable display device according to an embodiment, the roller **143** may be connected to one end of the display panel **10**. The display panel **10** may be wound or unwound so that the display panel **10** is in either a first state or a second state. The roller **143** may be configured to rotate in the arrow direction (clockwise) and raise the display part **20** and to rotate counterclockwise and lower the display part **20**. In an example, when the roller **143** operates in this manner, the display part **20** may be disposed in such a way that the front faces the $-z$ axis and the back faces the $+z$ axis. In this case, the display part **20** may be wound in such a way that the front where images are displayed faces the roller **143** outward. By winding the display part **20** in this way, when the display part **20** is raised out of the housing **30**, it is positioned in proximity to corners of the housing **30** to raise the display part **20**. Thus, a space for containing an object above the housing **30** in front of the screen of the display part **20** is eliminated, thereby preventing the screen from being blocked by the object positioned above the housing in front of the screen.

Alternatively, on the contrary, the display part **20** may be disposed in such a way that the front faces the $+z$ axis and the back faces the $-z$ axis.

In the rollable display devices according to one embodiment, source PCBs **120** may be disposed on at least part of the back (inside where the display panel **10** is wound around the roller) of the display part **20**. Each of the source PCBs **120** may be spaced apart from neighboring ones.

Signal lines for transmitting digital video data and timing control signals, which are transmitted from the timing controller board **105**, may be disposed on at least one source PCB **120**. The source PCB **120** may be connected to the display panel **10** by a source COF (chip on film **123**). The source COF **123** connected to one side of the source PCB

120 may be extended to the active region of the display panel **10** and connected to the display panel of the display part **20**.

A mounting portion **379** may be formed on an outer circumference of the roller **143**. The mounting portion **379** may be formed in such a way that part of the outer circumference of the roller **143** is stepped, in which case a receiving space **B** may be formed inside the roller **143**. The mounting part **379** may be positioned where the PCB **120** adjoins the roller **143** when the display part **20** is wound around the roller **143**.

When the display part **20** is rolled up, the source PCB **120** may be received in the receiving space **B** formed by the mounting portion **379**. Accordingly, it is possible to prevent damage to the source PCB **120** when the roller **143** is rolled up.

A timing controller board **105** may be mounted inside the roller **143**. The timing controller board **105** and the source PCB **120** may be electrically connected by an FFC cable **117**.

The roller **143** may include two bodies, rather than a single body, that is, an upper roller **331** and a lower roller **337**. The upper roller **331** and the lower roller **337** may be assembled together by various methods without any restraint. For example, they may be screwed together.

The timing controller board **105** may be mounted between the upper roller **331** and the lower roller **337**. The FFC cable **117** may be connected to the timing controller board **105** and the source PCBs **120** through a hole **331a** positioned in the upper roller **331**.

With this configuration, the timing controller board **105** rotates together with the roller **143**, thereby preventing the FFC cable **117** from being entangled. Also, the timing controller board **105** is mounted inside the roller **143**, thereby saving space.

Moreover, a main board and a power supply may be disposed inside the housing to drive the display part **20**. For example, they may be mounted on an inner wall surface of the housing. The timing controller board **105** may be connected to the main board and the power supply through wiring.

Hereinafter, a construction for raising the display part **20** will be described with reference to FIGS. **5** and **6**. FIG. **5** is a view showing the overall appearance of a rollable display device according to an embodiment. FIG. **6** is a view showing the appearance of a back of the rollable display device of FIG. **5**.

In an embodiment, the rollable display device **100** may include a link assembly **LA** for raising the display part **20**.

The link assembly **LA** may be driven by a motor. In the first state, the link assembly **LA** may be bent and positioned inside the housing **30** so that the display part **20** is positioned inside the housing **30** while wound around the roller **143**, and, in the second state, the display part **20** may be unfolded and come out of the housing **30**.

Meanwhile, the housing **30** may function as a mounting where the link assembly **LA** and the motor assembly **137** are installed, to thereby support the link assembly **LA** and the motor assembly **137**.

The housing **30** includes a first base **31** and a second base **33**, and the first base **31** and the second base **33** may face each other, with a predetermined distance between them. For reference, FIG. **5** illustrates the housing **30** from which the first base **31** is omitted to make the roller **143** visible.

The roller **143** may be disposed between the first base **31** and the second base **33**, and both ends thereof may be axially connected to the housing **30** so as to rotate clockwise or

counterclockwise. Accordingly, the roller **143** may rotate with respect to the central axis of the roller.

The link assembly LA may be disposed above the first base **31**. The link assembly LA may function to give support so that the display part **20** is raised or lowered. The link assembly LA may raise or lower a supporter **75** attached to the top of the display part **20**.

An upper end of the display part **20** may be fixed to the supporter **75**, and a lower end thereof may be fixed to the roller **143**. When the link assembly LA is unrolled (or unfolded), the display part **20** may be supported on the back so that the display part **20** is unfolded neatly without folds.

The motor assembly **137** may be positioned where the link assembly LA is connected to the housing **30**. The motor assembly **137** may be driven to raise or lower the link assembly LA. The motor assembly **137** may receive an electric signal and convert it into a physical force. The motor assembly **137** may transmit rotational energy to the link assembly LA to change it from the first state to the second state.

The link assembly LA may include the supporter **75** and a pair of links **73** supporting both sides of the supporter **75**.

The supporter **75** fixes ends of the display part **20**. Accordingly, the display part **20** may be raised in concert with the raising operation of the supporter **75**.

The link **73** may include an upper link **73a** and a lower link **73b**, and may have a bar shape. The upper link **73a** may be disposed at an upper portion, and the lower link **73b** may be disposed at a lower portion.

The upper link **73a** and the lower link **73b** may be connected through a joint **152**. One end of the upper link **73a** may be fastened to the supporter **75**, and the other end of the upper link **73a** may be fastened to the joint **152**. Also, one end of the lower link **73b** may be rotatably and axially connected to the motor assembly **137**, and the other end of the lower link **73b** may be fastened to the joint **152**.

The joint **152** may include gears (not shown) that are installed at the upper link **73a** and the lower link **73b**, respectively. The gear of the upper link **73a** and the gear of the lower link **73b** may engage each other. Thus, the links **73** may be configured to move symmetrically with respect to the joint **152**.

Such a link **73** may be provided on each of the left and right sides, and may operate as a pair. That is, the display part **20** may be raised in an upright position without tilting or creasing only when the left link and the right link are controlled to have the same momentum.

With this in consideration, in an embodiment, the link assembly LA may further include a shock absorber **72** supporting the link **73**. One end of the shock absorber **72** may be rotatably and axially connected to the link **73**, more precisely, the lower link **73b**, and the other end may be rotatably and axially connected to the first base **31**. In an exemplary embodiment, the shock absorber **72** may include an oil hydraulic cylinder, a pneumatic cylinder (or an air cylinder), or an actuator. The shock absorber according to this construction may include a piston and a cylinder, and the cylinder may be filled with oil or gas.

Hereinafter, an operation of the link assembly LA will be described with reference to FIGS. **6** to **8**. FIGS. **7** and **8** are views showing a link assembly in a folded state.

In the rollable display device **100** according to an embodiment, the links **73** may perform a rotating/pivoting motion by the operation of the motor assembly **137**, and, as a result, the supporter **75** may be raised.

The motor assembly **137** may operate so that the links **73** rotate or pivot in a direction in which they stand upright with

respect to the base **31**, by a gear construction (not shown) disposed between the motor assembly **137** and the lower link **73b**.

For example, the angle between the upper link **73a** and the lower link **73b** which are connected by the joint **152** as the axis of the motor assembly **137** rotates may be increased or decreased. Such an operation for decreasing or increasing the angle between the upper link **73a** and the lower link **73b** with respect to the joint as the upper link **73a** and the lower link **73b** are folded and unfolded may be referred to as a pivoting operation.

As the links **73** pivot, a top case may move toward the +y axis. Thus, the display part **20** whose one end is connected to the top case may be raised upward as it is unwound from the roller **143**.

As the links **73** pivot in a direction in which they stand upright with respect to the base **31**, the length of the shock absorber **72** varies. When the links **73** are unfolded, the shock absorber **72** whose one end is connected to the lower link **73b** is extended lengthwise, which increases oil pressure and support the links **73** to maintain an upright position.

When the motor assembly **137** pivots the lower link **73b** in a direction (clockwise) opposite to the direction in which the lower link **73b** stands upright with respect to the base **31**, the angle between the lower link **73b** and the upper link **73a** is decreased. As a result, the supporter **75** can be lowered toward the -y axis, and part of the display part **20** can be wound around the roller **143**. Also, as the motor assembly **137** pivots the lower link **73b** in a direction opposite to the direction in which the lower link **73b** stands upright with respect to the base **31**, the length of the shock absorber **72** can be decreased.

As such, as the lower link **73b** rotates clockwise or the links **73** pivot, the distance between the joint of the left link and the joint of the right link can become smaller. When the distance is minimum, the display part **20** can be completely contained in the housing. On the contrary, when the distance between the joint of the left link and the joint of right link is maximum, the links **73** can be brought to a fully upright position (90 degrees between the links and the base), thereby fully unfolding the display part **20**.

Hereinafter, the module cover **15** according to an embodiment will be described in more details with reference to FIG. **9**. FIG. **9** is a view showing the appearance of a module cover according to an embodiment.

In FIG. **9**, the module cover **15** according to an embodiment may be configured to have the shape of a thin plate. The module cover **15** may have a thickness of about 1 mm to 2 mm, and may vary with the size of the display panel **10**. For example, the thickness of the module cover **15** may become smaller as the size of the display panel **10** becomes smaller, and, on the contrary, the thickness of the module cover **15** may become larger as the size of the display panel **10** becomes larger. Also, the thickness of the module cover **15** may be adjusted according to its structural stiffness. The thickness may be increased to increase the structural stiffness, and on the contrary, the thickness may be decreased to decrease the structural stiffness.

Moreover, the thickness of the module cover **15** may be adjusted depending on the size of the roller **143**, more precisely, the diameter of the roller **143** which is cylindrical. For example, if the diameter of the roller **143** is increased, the radius of curvature required for the display part **20** is increased that much and therefore the thickness of the module cover **15** may become larger. On the contrary, if the

diameter of the roller **143** becomes smaller, the radius of curvature required for the display part **20** becomes smaller proportionally.

The module cover **15** according to an embodiment may have a sandwich structure. The sandwich structure has the advantages of light weight and high structural stiffness because it is made by putting a lightweight core between two outer plates.

The module cover **15** according to an embodiment may include a first skin **151** and a second skin **153** facing the first skin **151**, and a core **155** disposed between them. Here, the core **155** is not an essential component, and the core **155** may be omitted as long as the structural stiffness permits.

The first skin **151** may have, but not limited to, a thickness of about 0.1 to 0.3 mm, and its thickness may be adjusted in consideration of structural stiffness, bending strength, or buckling stress.

Preferably, the first skin **151** may have a lower bending strength or buckling stress than the second skin **153** so as to enable bending in one direction. The lower the bending strength or buckling stress, the better the skins bend and roll. In an exemplary embodiment, the difference in buckling stress between the first skin **151** and the second skin **153** is preferably 10 or greater. If the difference in buckling stress is 10 or greater, the display part **20** may be unfolded without a hitch such as creases or wrinkles.

In contrast, the second skin **153** may have a different bending strength or buckling stress from the first skin **151** so that the module cover **15** bends in one direction. For example, the greater the difference in bending strength or buckling stress between the first skin **151** and the second skin **153**, the better they bend and roll.

With this in consideration, the thickness of the second skin **153** may be at least equal to or smaller than the thickness of the first skin **151**. The bending strength or buckling stress tends to increase in proportion to the thickness. Thus, if one skin has higher bending strength and the other skin has lower bending strength, the bending strength may roll smoothly toward the skin having the lower bending strength.

This will be described with reference to FIG. **10**. In the module cover **15** according to an embodiment, the buckling stress of the first skin **151** may be lower than the buckling stress of the second skin **153**. For example, the difference in buckling stress between the first skin **151** and the second skin **153** may be 10 or greater.

The buckling stress of the first skin **151** disposed in the first direction is relatively much lower than the buckling stress of the second skin **153** disposed in the second direction. In this state, when the module cover **15** is bent in a first direction (or counterclockwise), the bending occurs with respect to the first skin **151** (the first skin is positioned on the inside and the second skin is positioned on the outside, with respect to the axis of rotation), the bending in the first direction may occur easily.

On the contrary, if the module cover **15** bends in a second direction (or clockwise), the bending occurs with respect to the first skin **151** (the second skin is positioned on the inside and the first skin is positioned on the outside, with respect to the axis of rotation), the bending in the second direction may occur less than the bending in the first direction.

Moreover, the first skin **151** constituting the module cover **15** may be made inextensible so as not to bend in the second direction. If the module cover **15** bends clockwise (or in the second direction), the first skin **151** may be subject to tension. Accordingly, if the first skin **151** is extensible, the module cover **15** may bend clockwise.

However, in an example, since the first skin **151** is inextensible, the module cover **15** may bend in the first direction but not in the second direction.

Meanwhile, as illustrated in FIG. **11**, the module cover **15** thus constructed may be joined to the display panel **10** so that the second skin **153** faces the display panel **10**. More precisely, the display panel **10** and the module cover **15** may be attached together, with the back of the display panel **10** and the second skin **153** of the module cover **15** facing each other.

As a result, when the roller **143** rotates clockwise, the display part **20** bends with respect to the first skin **151**, allowing the display part **20** to be rolled around the roller **143**. On the contrary, when the roller **143** rotates counterclockwise, the display part **20** may be unwound from the roller **143** and raised. Also, once the module cover **15** is fully unfolded, the display part **20** may be prevented from bending in the second direction because of the first skin **151** which is inextensible in the second direction. Accordingly, when fully unfolded, the display part **20** may be unfolded flat by the support force in the second direction.

In an exemplary embodiment, the first skin **151** may contain less polymer matrix composites than the second skin **153** or contain no polymer matrix composites. Since the polymer matrix composites function to increase stiffness or hardness, the first skin **151** whose bending strength or buckling stress is relatively smaller than the first skin **151** may contain less polymer matrix composites than the second skin **153**, or the first skin **151** may contain no polymer matrix composites.

As the second skin **153** contains polymer matrix composites, its weight may be lessened and its stiffness may be increased, thereby preventing the display part **20** from bending (or falling forward) in the second direction.

Moreover, at least one of the first skin **151** and the second skin **153** may be made of reinforced fiber as a main component. As for the main component, the proportion of reinforced fiber is 50 (wt %) or greater, and, more preferably, the proportion of reinforced fiber may be 90 (wt %) or greater. Here, the reinforced fiber includes glass fiber or carbon fiber.

At least one of the first skin **151** and the second skin **153** is configured to include reinforced fiber. Thus, when the display part **20** is wound around the roller **143** and then unwound from it, the display part **20** may be easily unrolled due to intrinsic elastic restoring force.

In addition, in an embodiment, a first reinforced fiber included in the first skin **151** may be woven in a different way from a second reinforced fiber included in the second skin **153**. This will be described in detail with reference to FIGS. **12** to **15**. FIGS. **12** and **13** are views illustrating cross-section structures of a first skin and a second skin, respectively. FIGS. **14** and **15** are views illustrating the direction of arrangement of reinforced fiber.

Referring to these drawings, the first skin **151** and the second skin **153** may have a cross-section structure in which a plurality of sub skins are laminated. Here, each layer of the skins **151** and **153** may be classified according to the direction in which original yarns of reinforced fiber, for example, carbon yarns, are woven.

For example, the first skin **151** may be made up of a plurality of layers formed by weaving carbon yarns only in one direction. In the drawings, "x" indicates that carbon yarns are woven in a first direction.

As exemplified in FIG. **12**, the first skin **151** may be made up of a plurality of sub skins **151a**, and the carbon yarns of each layer may be arranged only in the first direction.

Also, for example, the second skin **153** may include first sub skins **153a** with carbon yarns woven only in the first direction and second sub skins **153b** with carbon yarns woven in a second direction orthogonal to the first direction. In the drawings, “+” indicates that carbon yarns are woven in the second direction.

In an exemplary embodiment, the second skin **153** may further include second sub skins **153b** woven in the second direction since it is required to have higher buckling stress than the first skin **151**. More preferably, the second skin **153** may be formed in such a way that the number of second sub skins **153b** is larger than the number of first sub skins **153a**. Here, the first sub skins **153a** and the second sub skins **153b** are laminated or arranged freely without being limited to any specific order or arrangement. For example, the first sub skins **153a** and the second sub skins **153b** may be arranged in an alternating fashion, or a plurality of first sub skins **153a** may be laminated and then a plurality of second sub skins **153b** may be laminated thereon, thereby forming the second skin **153**.

With this configuration, the second skin **153** may bend more easily with respect to the second direction than with respect to the first direction, and therefore may have a support force in the second direction.

Meanwhile, FIGS. **14** and **15** are views showing the direction of arrangement of original yarns of the first sub skins **153a** and the second sub skins **153b**.

The first sub skins **153a** may be a layer at which the original yarns **153a1** are all arranged in the first direction (the y-axis direction in the drawings). Accordingly, the original yarns **153a1** may be weft yarns between warp yarns and weft yarns.

Also, the second sub skins **153b** may be a layer at which the original yarns **153b1** are arranged only in the second direction (the x-axis direction in the drawings) orthogonal to the first direction. Accordingly, the original yarns **153b1** may be warp yarns.

By the way, the bending strength of the first sub skins **153a** in the first direction may be much greater than the bending strength thereof in the second direction. In other words, the first sub skins **153a** may easily deform in the first direction which is along the axis **V1** since the original yarns **153a1** are arranged in the first direction, whereas it may be difficult for the first sub skins **153a** to bend in the second direction which is along the axis **V2**.

Accordingly, when the display part **20** rolls in the first direction, it may be difficult for the first sub skins **153a** to bend in the rolling direction, and the second sub skins **153b** may bend easily in the rolling direction.

Consequently, if the original yarns of each sub skin constituting the first skin **151** are arranged in a direction orthogonal to the rolling direction, the first skin **151** may bend easily in the rolling direction.

On the other hand, the second skin **151** does not bend easily compared to the first skin **151**, because the original yarns are disposed in a complex way in the first and second directions. However, the second skin **153** has sub skins including original yarns arranged in the same direction as the rolling direction of the display part **20**, which causes a build-up of elastic restoring force when the display part **20** bends. Accordingly, when the display part **20** is unfolded, it may be elastically unrolled, and, as a result, creases or wrinkles formed when the display part **20** is unfolded may be prevented.

With this in consideration, in the second skin **153**, the number of first sub skins **153a** and the number of second sub skins **153b** may be different, and, more preferably, the

number of sub skins arranged in the same direction as the rolling direction of the display part **20** may be larger than the number of other sub skins.

In one configuration, the skins **151** and **153** include a plurality of sub skins with original yarns arranged in one direction. Thus, the properties of layers required for each skin, such as bending strength or buckling stress, may be easily implemented.

Hereinafter, the core constituting the module cover **15** will be described in detail with reference to FIG. **16**. FIG. **16** is a view showing a plane pattern of the core, in which (A) shows an enlarged view of part of the honeycomb.

In one configuration, the core **155** may be constructed of a honeycomb structure which is configured as a set of hexagonal columns **155a** for structural stiffness.

The core **155** may include hexagonal columns **155a** whose horizontal to vertical ratio is high so that the display part **20** is folded or unfolded as it rolls in the rolling direction (the y-axis direction in the drawings).

Here, as illustrated in the drawings, the rolling direction is the first direction (the y-axis direction in the drawings), for example. If the rolling direction is the first direction, this means that the display part **20** winds or unwinds with respect to the axis **C1** of rotation in the second direction.

Assuming that the rolling direction of the display part **20** is the first direction (the y-axis direction in the drawings), it is preferable that the width **B2** of the hexagonal columns **155a** in the second direction is larger than the width **B1** thereof in the first direction. In this instance, the height of the hexagonal columns **155a** is not taken into consideration to identify the relationship between the width **B2** in the second direction and the width **B1** in the first direction.

More preferably, the ratio **B2/B1** of the width **B2** in the second direction and the width **B1** in the first direction may be from 1.5 to 7. In other words, the width **B2** in the second direction may be a minimum of 1.5 times the width **B1** in the first direction and a maximum of 7 times the width **B1**. If the width **B2** in the second direction is smaller than a minimum of 1.5 times the width **B1** in the first direction, the display part **20** may not bend with a desired radius of curvature due to the structural stiffness of the core **155**. Also, if the width **B2** in the second direction is larger than 7 times the width **B2** in the first direction, the structural stiffness of the core **155** may be too low to maintain shape.

Moreover, the ratio **B1/G1** of the thickness **G1** of the hexagonal columns **155a** and the width **B1** in the first direction may be from 3 to 20. In other words, the thickness **G1** may be a maximum of $\frac{1}{3}$ of the width **B1** in the first direction and a minimum of $\frac{1}{20}$ of the width **B1** in the first direction.

If the column thickness **G1** is smaller than $\frac{1}{20}$ of the width **B1** in the first direction, the columns are too thin to obtain enough structural stiffness for maintaining shape. Even if the column thickness **G1** is larger than $\frac{1}{3}$ of the width **B1** in the first direction, the structural stiffness is too high, making it practically impossible to bend the display part **20** in the rolling direction.

The first skin **151** may be joined to one side of the thus-constructed core **155**, and the second skin **153** may be joined to the other side so as to face the first skin **151**. Here, the skins **151** and **153** may be joined to the core **155** through an adhesive layer. In this case, the shore hardness of the adhesive layer may be preferably 80 or smaller. If the shore hardness of the adhesive layer is greater than 80, it may be difficult to roll the display part **20** around the roller **143**.

In addition, the thickness of the skins **151** and **153** may be equal to or smaller than 1% of the bending strength of the

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core. If the thickness of the skins **151** and **153** is larger than 1% of the bending strength of the core, the stiffness of the skins or the thickness of the skins becomes larger, which may make it difficult to roll the display part **60** around the roller **143** due to the strength of the skins **151** and **153**.

Hereinafter, another embodiment of the display part **20** will be described with reference to the accompanying drawings. FIG. **17** is a view showing the overall appearance of a display part according to another embodiment. FIG. **20** is a view showing the display part of FIG. **17** taken along the line B-B'.

Referring to these drawings, the display part **20** according to this embodiment may include a module cover **15** including a bending portion **15a** and a display panel **10** joined to one side of the module cover. The same configuration as the above-described module cover may apply to the module cover **15**.

The module cover **15** of this embodiment may further include a bending portion **15a** so that the module cover **15** has elastic restoring force. Assuming that the rolling direction of the display part **20** is the first direction (the y-axis direction in the drawings), the bending portion **15a** may be formed by bending both ends of the module cover **15** in the second direction (the x-axis direction in the drawings) in one direction.

Accordingly, the module cover **15** and **20** may be divided up into a bonding area BA and a non-bonding area NBA. Here, the bonding area BA may be an area with a flat surface where the display panel **10** is bonded, and the non-bonding area NBA may correspond to both ends of the module cover **15** where the display part **10** is not bonded. The bending portion **15a** may be formed in the non-bonding area NBA.

The bending portion **15a** may be formed in such a way that the module cover **15** is curved with a certain radius of curvature, or may be formed in such a way that an end portion thereof is bent at a certain angle. Moreover, the bending portion **15a** may be formed in various ways without being limited to any particular shape, apart from the shape exemplified in the drawings, as long as it has elastic restoring force. Additionally, although the bending portion **15a** is configured as part of the module cover **15**, a separate material may be added to the module cover **15**.

In an exemplary embodiment, the bending part **15a** may be formed by bending the first skin, second skin, and core of the module cover **15** altogether, or may be formed by selectively bending the second skin **153** alone which has the highest elastic restoring force (see FIG. **21**). In this instance, the height t1 of the bending portion **15a** may be greater than the sum t2 of the thickness of the core **155** and the thickness of the first skin **151**. According to an example, the display panel **10** may be joined to face the second skin **155**, so that the display part **20** may be rolled around the roller **143** (outward folding). Accordingly, it is necessary for the bending portion **15a** to be bent toward the first skin **151** so as to have elastic restoring force, and therefore the height t1 of the bending portion **15a** should be greater than the sum t2 of the thickness of the core **155** and the thickness of the first skin **151**.

Moreover, it is preferable that the bending portion **15a** is bent toward the roller **143** so as to have elastic restoring force when wound around the roller **143**. FIG. **19** illustrates the module cover **15** when wound around the roller and when unwound from the roller.

When the module cover **15** is unwound from the roller, the bending portion **15a** may have a first height h1. In this state, no deforming force may be exerted on the bending portion

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15a. Here, the height h1 of the bending portion **15a** refers to the linear height from the roller **143** to the module cover **15**.

Also, when the module cover **15** is bent around the roller, the deforming force (indicated by the arrow in the drawing) on the bending portion **15a** is continuously exerted toward the roller **143** while the display part **20** is rolled around the roller **143**. Thus, the second height h2 of the bending portion **15a** is decreased compared to when in the first state. Meanwhile, the bending portion **15a** may store this deforming force as elastic restoring force, and the display part **20** may function to stand upright by itself when unfolded.

In an exemplary embodiment, the ratio h1/h2 of the first height h1 when the bending portion **15a** is unrolled from the roller and the second height h2 when the display part is rolled up around the roller may be 1 to 5. In other words, the first height h1 of the bending portion **15a** may be a minimum of the second height h2 and a maximum of five times the second height h2. If the first height h1 of the bending portion **15a** is equal to or smaller than the second height h2, no deforming force is exerted on the bending portion **15a**, and if the first height h1 of the bending portion **15a** is five times the second height h2 or greater, the yield strain of the bending portion **15a** may be exceeded due to the deforming force exerted on the bending portion **15a**.

The display part **20** of this embodiment stores elastic restoring force when the display part **20** is wound (see FIG. **18**) around the roller **143** due to the bending portion **15a**, and increases the self-standing stiffness of the display part **20**. Therefore, the display part **20** may be easily unfolded, or the display part **20** may be raised only by rotating the roller without mechanical assistance such as of the above-described link assembly.

The aforementioned embodiments of the disclosure are not exclusive or different. The elements or functions of each of the aforementioned embodiments of the disclosure may be used in combination with or combined with each other.

The detailed description should not be construed as being limitative, but should be considered to be illustrative from all aspects. The scope of the disclosure should be determined by reasonable analysis of the attached claims, and all changes within the equivalent scope of the disclosure are included in the scope of the disclosure

The invention claimed is:

1. A rollable display device comprising:

a display part including a display panel and a module cover supporting the display panel; and
a roller configured to roll and unroll the display part into and out of a housing,

wherein the module cover includes:

a bonding portion joining the display panel to the module cover; and
elastic bending portions at both ends of the bonding portion of the display part, and bending toward the roller,

wherein when the display part is unrolled from the roller and exposed outside of the housing, the elastic bending portions elastically bend to have a first height,

wherein when the display part is rolled around the roller, and positioned inside the housing, the elastic bending portions elastically bend to have a second height that is less than the first height, and

wherein the module cover further comprises:

a first skin facing the roller;

a second skin facing the display panel; and

a core portion sandwiched between the first skin and the second skin,

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- wherein the second skin has a buckling stress greater than a buckling stress of the first skin.
2. The rollable display device of claim 1, wherein the module cover comprises:
 - a first side facing the roller;
 - a second side facing the display panel; and
 - a core portion sandwiched between the first side and the second side, and
 wherein a bending strength of the first side is different than a bending strength of the second side.
 3. The rollable display device of claim 2, wherein the bending strength of the second side is greater than the bending strength of the first side.
 4. The rollable display device of claim 1, wherein a ratio $h1/h2$ of the first height $h1$ and the second height $h2$ of the bending portion is from 1 to 5.
 5. The rollable display device of claim 1, wherein the first skin contains less polymer matrix composites than the second skin or contains no polymer matrix composites.
 6. The rollable display device of claim 1, wherein the difference in buckling stress between the first skin and the second skin is 10 or greater.
 7. The rollable display device of claim 5, wherein at least one of the first skin and the second skin contains reinforced fiber.
 8. The rollable display device of claim 7, wherein a first reinforced fiber included in the first skin is woven in a different way from a second reinforced fiber included in the second skin.
 9. The rollable display device of claim 8, wherein the second reinforced fiber comprises first sub skins with original yarns arranged only in a first direction and second sub skins with original yarns woven in a second direction orthogonal to the first direction, and
 - wherein the first direction is the same as the direction in which the display part rolls, and the number of first sub skins is larger than the number of second sub skins.
 10. The rollable display device of claim 8, wherein the first reinforced fiber only comprises a plurality of sub skins woven in the first direction.

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11. The rollable display device of claim 6, wherein a thickness of the second skin is equal to or larger than a thickness of the first skin and is equal to or smaller than 1 mm.
12. The rollable display device of claim 1, wherein the core portion has a honeycomb structure comprising hexagonal columns, and
 - wherein a width of the hexagonal columns in a first direction corresponding to rolling direction is smaller than a width of the hexagonal columns in a second direction perpendicular to the first direction.
13. The rollable display device of claim 12, wherein a ratio $B2/B1$ of the width $B2$ in the second direction and the width $B1$ in the first direction is from 1.5 to 7.
14. The rollable display device of claim 12, wherein a ratio $B1/G1$ of a thickness $G1$ of the hexagonal columns and the width $B1$ in the first direction is from 3 to 20.
15. The rollable display device of claim 12, wherein a thickness of at least one of the first and second skins is equal to or smaller than a bending strength of the core portion.
16. The rollable display device of claim 1, wherein the second skin is joined to the core portion by an adhesive layer, and a shore hardness of the adhesive layer is 80 or smaller.
17. The rollable display device of claim 1, wherein the bending portions are formed only on end portions of the second skin.
18. The rollable display device of claim 1, wherein a height of the elastic bending portions is greater than a sum of a thickness of the first skin and a thickness of the core.
19. The rollable display device of claim 1, further comprising:
 - a link assembly including a supporter fixed to an end portion of the display part, an upper link rotatably mounted on the supporter, and a lower link connected to the upper link through a joint; and
 - a motor assembly for rotating the lower link.

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